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USDA

United States Department of Agriculture

Animal and Plant Health Inspection Service

Miscellaneous Publication No. 1591

Innovative Solutions to Human–Wildlife Conflicts

National Wildlife Research Center Accomplishments 2003

United States Department of Agriculture
Animal and Plant Health Inspection Service
Wildlife Services

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Issued January 2004

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USDA

INTRODUCTION

National Wildlife Research Center—Mission and Location

The mission of the U.S. Department of Agriculture's (USDA) Wildlife Services (WS) program is to provide Federal leadership in managing problems caused by wildlife. The National Wildlife Research Center (NWRC) functions as the research arm of WS by providing scientific information on the development of socially acceptable methods for wildlife damage management. As part of WS' strategic plan to improve the coexistence of people and wildlife, NWRC has identified four strategic program goals: (1) developing methods, (2) providing wildlife services, (3) valuing and investing in people, and (4) enhancing information and communication. WS is dedicated to helping meet the wildlife damage management needs of the United States by building on NWRC's strengths in these four key areas. This annual research highlights report is structured around these program goals.

The headquarters of the NWRC is located on 43 acres on the Foothills Research Campus of Colorado State University (CSU) in Fort Collins, CO. During 2003, NWRC made significant progress toward building out its master plan on that site. Construction was completed on an outdoor animal research facility and associated research support structures, and on an office and animal support addition to the Center's existing indoor Animal Research Building. Architectural and engineering drawings also were completed on new facilities in which to conduct research on invasive species. In addition, a portion of the Center's Animal Research Building was modified into Biosafety Level 3 to allow Center scientists to conduct wildlife disease research. Completion of the Center's master plan over the next several years will enhance NWRC's reputation as the only wildlife research complex of its kind in the world devoted exclusively to providing new, science-based solutions to the complex issues of wildlife damage, human health and safety (including wildlife diseases) problems, and invasive species.

DEVELOPING METHODS

Goal: Increase effective methods available for wildlife damage management.

BIRD RESEARCH PROGRAM

Title: Economic Impact and Management of Bird Predation at Aquaculture Facilities in the Southeastern United States

Goal: Determine the magnitude of and develop methodology to reduce damage by cormorants, wading birds, and pelicans on southern catfish, baitfish, and crawfish farms.

Fish-eating birds can have a substantial economic impact on aquacultural production. Annual costs associated with bird damage and damage prevention for aquaculture industries is estimated to exceed $17 million. Double-crested cormorants, American white pelicans (AWP), and several wading birds are the predominant species associated with these conflicts. In addition to conflicts with aquaculture, double-crested cormorants have also been associated with habitat changes throughout North America. Present NWRC aquaculture research is aimed at acquiring information regarding the abundance, foraging behavior, economic impacts, and damage-management techniques associated with fish-eating birds near southeastern aquaculture facilities. Since these birds annually migrate from northern breeding areas to southeastern wintering grounds, the Center's research efforts should provide the information necessary to develop and evaluate management alternatives for fish-eating birds throughout their range.

American White Pelican Ecology— Commercial catfish production has increased dramatically since 1985 in the Southeastern United States. During this period, problems associated with fish-eating birds at aquaculture facilities have also increased and diversified. AWP are one of the major species of concern because of their appetite for fish and their potential to spread fish diseases and parasites from farm to farm.

NWRC scientists have conducted a variety of studies to learn more about the biology of AWP and their impact on southern aquaculture. NWRC research indicates that pelicans consume up to 3 pounds of catfish per foraging session. In a collaborative study with the U.S. Geological Survey's (USGS) National Wetlands Research Center, NWRC biologists determined that although the largest number of pelicans was in coastal Louisiana (up to 35,000), the average flock sizes generally were larger in Mississippi (245 birds/flock), where catfish production was greatest. However, pelicans were observed more frequently in natural wetland habitats rather than catfish ponds during most winter and spring surveys. Use of catfish ponds by pelicans was greater than other habitats only in April, immediately before and during their spring migration. Also, during

winter 2002–03, NWRC biologists fitted 23 pelicans with satellite transmitters in the Mississippi River delta to integrate Geographical Information System information on pelican movements as it relates to the aquaculture industry. When completed the results of this study will lead to a better understanding of the timing of pelican distribution and habitat use, which will help researchers determine the impacts of this bird on aquaculture and develop strategies for reducing those impacts.

Wood Stork Research—In August 2002, biologists from NWRC's Mississippi field station initiated a collaborative study with researchers from the Savannah River Ecology Lab (SREL) Wood Stork Project, the U.S. Fish and Wildlife Service (USFWS), and WS in Mississippi, Alabama, and Louisiana to determine the potential for wood storks to cause damage to catfish aquaculture in the Southeast. The first phase of the study is evaluating foraging behavior of wood storks on cultured catfish at the field station aviary. Preliminary results indicate that although storks are capable of eating catfish fingerlings, in a production setting storks do not appear to search out catfish as a preferred prey.

NWRC biologists have also begun to investigate the level of use of aquaculture facilities by storks. As part of this study, biologists are monitoring catfish farms throughout Alabama, Arkansas, Louisiana, and Mississippi to estimate the number of stork-days spent on these facilities. This information is being combined with the results of the foraging experiments to determine the potential impacts that storks pose to the catfish industry. A third phase of the study will use satellite technology to evaluate movements of wood storks in relation to aquaculture in the Southeast.

TITLE: Develop New and Improved Uses of Vulture Effigies and Population Models To Reduce Vulture Damage to Property, To Control Predation on Livestock, and To Disperse Nuisance Roosts

GOAL: Develop practical, effective uses of taxidermic and artificial effigies to manage predation, aviation safety, and property damage problems caused by black and turkey vultures. Examine population genetics and modeling as means to evaluate vulture responses to lethal control.

Vulture populations are increasing nationwide, particularly in the Southeastern United States. As vulture numbers increase, so do conflicts with human activities. Black vultures, for example, damage vinyl, plastic, and other synthetic construction and insulation material. Additionally, black vultures prey on newly born livestock and, in association with turkey vultures, form roosts that not only are nuisances (e.g., they can cause electric power outages) but also contribute to human health and safety problems. Vultures often forage at landfills, which in turn are often located near airports. In their daily flights to and from landfills to feed, vultures constitute a major hazard to aircraft. Problems related to vulture management show no sign of diminishing, and the need for effi-

cient, practical, and safe methods of managing vulture damage situations is acute.

Reducing Hazards to Aircraft From Vultures at Pt. Mugu, CA—During December 2002, a wildlife biologist from NWRC's Florida field station provided technical assistance for dispersing vulture roosts to biologists at Naval Base Ventura County, Pt. Mugu, CA. A flock of 18 to 25 turkey vultures roosted in 2 stands of eucalyptus trees at the faclity, a weapons testing base used by several types of aircraft. In addition to causing a nuisance at the roosts with their droppings, the birds created a bird-strike risk as they left the roost trees and soared over the runways. To eliminate vulture roosting on the base and to reduce the bird-strike risk, a turkey-vulture effigy was installed in one of the eucalyptus tree roosts. Vultures immediately discontinued the use of that roost, and overall vulture numbers around the base decreased to five. Four subsequent days of observation revealed only four birds in the second roost and only two soaring near the runways. Six months later, the roost remained free of vultures.

Evaluation of Roost Dispersal via Artificial Vulture Effigies—Biologists at the NWRC's Florida field station tested an artificial vulture effigy at a roost in the town of White Springs, FL. Approximately 120 black and turkey vultures roosted in a 1-ha wooded lot, where their droppings created a major nuisance for nearby residents.

After several days of documenting vulture numbers in the roost at sunrise, the biologists installed an artificial effigy. The effigy was a 38-cm-tall decorative bird, made with feathers glued to a hard foam body with plastic, raptorlike head and feet. The effigy was modified to more closely resemble a turkey vulture by removing feathers from the head and the feathered neck collar and by painting the head and feet.

The morning after the effigy was installed, the roost was devoid of vultures. Although vulture numbers increased somewhat during the next 2 days, activity declined thereafter, and all birds were gone 10 days after installation. The effigy was removed after 8 weeks; there was no further indication of vultures returning to the site.

TITLE: Management of Bird Damage to Rice

GOAL: Develop new or improved management strategies for reducing bird damage to rice.

Red-winged blackbirds, common grackles, and brown-headed cowbirds cause extensive damage to newly planted rice and ripening rice. NWRC researchers are focused on reducing bird damage to rice and improving profitability to growers by developing new or improved management strategies and expanding partnerships between rice producers, rice commodity groups, rice research boards, universities, and local, State, and Federal agencies.

DRC–1339 Operational Baiting in Louisiana and Texas Has Little Impact on Nontarget Species—Blackbird damage to newly planted rice is an economically important problem for many producers in Louisiana, Texas, Arkansas, and Missouri. Although the avicide DRC–1339 has been used to manage blackbird populations that congregate at staging areas prior to rice planting, Federal, State, and private groups have concerns that it could be hazardous to nontarget birds that are attracted to bait sites. Between 2000 and 2001, NWRC scientists monitored the use of DRC–1339 bait sites by nontarget birds during operational baiting programs in Louisiana and Texas.

In Louisiana, 316 observations were made at 55 bait sites over a 158-hour period, and 312 flush-counts of birds were conducted. In Texas, 182 observations at 26 bait sites were conducted over a 91-hour period, and 174 flush-counts of birds were conducted. Savannah sparrows were the nontarget bird species most commonly observed in both Louisiana and Texas. However, mourning doves in Louisiana and meadow larks in Texas are of greater concern because of their foraging habits, susceptibility to DRC–1339, and frequency and rate of occurrence at DRC–1339 bait sites.

NWRC scientists also conducted tests to determine the dietary toxicity of DRC–1339 to savannah sparrows, Canada geese, snow geese, mourning doves, western meadow larks, and American tree sparrows—all nontarget species that have been observed on DRC–1339 bait sites.

During 5-day dietary tests in which birds were fed 2-percent DRC–1339-treated brown rice diluted 1:25 with untreated brown rice, no mortality occurred among Canada geese or snow geese, and only one savannah sparrow died. During the same test, 9 of 10 mourning doves, 8 of 9 meadow larks, and 8 of 10 American tree sparrows died. These results indicate that mourning doves, meadow larks, and American tree sparrows that consume DRC–1339 baits are at risk.

Estimating the "Take" of Blackbirds From DRC–1339 Bait Sites—To better estimate the take of target blackbirds during DRC–1339 baiting operations, in 2002 NWRC scientists initiated a 2-year study at 12 baiting sites in Louisiana. Birds were collected as they departed the bait sites, and their esophagus and gizzard contents were analyzed to determine the number of rice grains consumed by birds at bait sites. In all, 524 red-winged blackbirds, 45 brown-headed cowbirds, 27 common grackles, and 1 yellow-headed blackbird were collected.

Red-winged blackbird males and females consumed an average of 32 and 26 rice grains, respectively. Brown-headed cowbird males and females consumed an average of 36 and 33 rice grains, respectively. Common grackle

males and females consumed an average of 69 and 77 rice grains, respectively. Yellow-headed blackbird males and females consumed an average of 61 rice grains each.

By ranking blackbirds by species and rice grain consumption, estimates of take can be calculated. For example, 6 percent of the red-winged blackbirds that were collected consumed no rice grains, 56 percent consumed between 1 and 25 rice grains, and 38 percent consumed >25 rice grains. The 262 red-winged blackbirds that consumed <25 rice grains consumed a total of 3,146 rice grains, whereas the 230 red-winged blackbirds that consumed >25 rice grains consumed a total of 11,001 rice grains.

In 2003, more than 2,400 blackbirds and 200 nontarget birds also were collected at DRC–1339 bait sites in Louisiana, Texas, and Missouri for analysis of esophagus and gizzard contents. The data from this study are being used to construct a predictive model for estimating the take of target and nontarget birds from DRC–1339 baiting operations on blackbird staging sites. These numbers will be combined with information on species, sex, bait distribution, and concentration of active ingredient to construct a predictive model for estimating the take of blackbirds from DRC–1339 baiting operations.

Evaluation of Candidate Blackbird Repellants for Rice—Scientists at NWRC headquarters in Fort Collins and at the Center's Florida field station conducted a series of screening tests to evaluate caffeine, benzamide (Moncut™), azadirachin (Aza-Direct™), and neem oil as potential repellants for reducing bird damage to both newly planted seed and ripening rice. Captive birds were offered rice seed treated with caffeine at one of three levels: 0.1 percent, 0.15 percent, or 0.25 percent.

At the 0.25-percent treatment rate, rice consumption by male brown-headed cowbirds was reduced 72 percent relative to a control group of birds offered untreated rice. For female red-winged blackbirds, best results occurred at the 0.15-percent treatment rate, which reduced rice consumption by 56 percent relative to the control group. For male red-winged blackbirds, the 0.25-percent treatment resulted in 76-percent reduction in rice consumption. Moncut treated at 1.1 percent was offered to blackbirds in both one-choice and no-choice tests. During the treatment phase of each test, consumption of treated rice was lower than that of untreated rice in the one-choice test. Consumption of treated baits decreased about 50 percent during the first day of treatment in the no-choice test but returned to normal by day 4. Neem oil was not effective as a repellant at 0.25 percent. Aza-Direct is currently being tested. NWRC is conducting additional trials to further evaluate caffeine and Moncut as potential blackbird feeding deterrents.

Bird Shield® Product Ineffective in Reducing Blackbird Activity in Ripening Rice—In Missouri, acreage planted to rice has increased rapidly in recent years. Coincident with this increase, blackbird damage to the crop has also increased. Nonlethal repellants offer a potential method of alleviating bird damage to rice. NWRC scientists conducted

field trials to evaluate Bird Shield, a commercial bird-repellent product recently registered with the U.S. Environmental Protection Agency (EPA) for use on ripening rice. This product uses methyl anthranilate, a Food and Drug Administration (FDA)-approved food additive, as the active ingredient.

In Missouri during September 2002, NWRC personnel from the Florida field station and Fort Collins assisted Missouri WS personnel in assessing the usefulness of this product as a blackbird repellant in rice. Five fields that were being damaged by thousands of blackbirds were aerially sprayed with Bird Shield at the recommended rate of 1.7 L/ha. Fields were observed daily, before and after application of the repellant, to monitor bird activity and evaluate efficacy.

The number of blackbirds recorded remained unchanged in four of the treated fields and decreased in the fifth. However, bird numbers were already decreasing in the latter field prior to treatment, indicating that the repellant probably had little effect on bird activity. These findings suggest that Bird Shield adds little to the rice producers' options for protecting rice from blackbirds.

Aza-Direct™ Repellancy Tests for Blackbird Control in Rice—NWRC researchers in Fort Collins have completed experiments at the Center's Outdoor Animal Research Facility to test the repellancy of Aza-Direct™ as a potential repellant for blackbirds causing damage to newly planted rice and ripening rice. The compound is a biological insecticide currently registered with EPA by its manufacturer, Gowan Company. The registered insecticide (active ingredient: azadirachtin) was applied at various concentrations (0.5 percent–2.8 percent) on rice seed to evaluate blackbirds' response.

Relative to baseline (pretreatment) rice consumption, blackbirds' rice consumption was reduced by only 5 to 25 percent over the 4-day, no-choice posttreatment period. NWRC is cooperating with several chemical companies to evaluate other potential chemical compounds as possible repellants for rice.

TITLE: Development and Evaluation of Management Techniques for Reducing Blackbird Damage to Ripening Sunflower Crops and Feedlots

GOAL: Develop new and/or improved methods to reduce blackbird damage to ripening sunflower crops and feedlots.

Blackbirds and starlings are responsible for damaging grain crops and sunflowers and eating livestock feed. NWRC investigators are evaluating the efficacy and environmental impacts of using DRC–1339 to reduce blackbird and starling populations and nonlethal repellent techniques to reduce their damage to crops.

Modeling of Blackbird Populations Breeding in Central North America—Blackbird depredation of sunflower in central North America is a serious agricultural problem. To understand the full scope of the damage and develop mathematical models to evaluate outcomes of different management strategies aimed at reducing blackbird damage to sunflower, scientists need accurate estimates of blackbird populations. Several areas within and surrounding the sunflower-growing region have only relative measures of bird abundance from the North America Breeding Bird Survey. NWRC scientists attempted to derive population density estimates in five physiographic regions where only the Survey's indices were available.

Scientists assumed a linear relationship between these indices and population densities of territorial males in two physiographic

regions in North Dakota. The linear relationship is a sound assumption because of the openness of the landscapes and the relatively easy detection of male blackbirds during the breeding season. This relationship showed that of every individual territorial male observed on a legal quarter-section (0.5 mi), seven blackbirds were counted on the Survey's routes. NWRC scientists, therefore, estimated an average of 52 million breeding blackbirds as being present in the sunflower-growing region and adjacent areas (~180,000 mi^2), an area which encompassed portions of North Dakota, South Dakota, Minnesota, and the western prairie provinces of Canada.

North Dakota harbored the largest number of breeding blackbirds, with an estimated 21 million. Following recruitment of young, the late-summer population within the confines of the sunflower-growing region and its surrounding areas was estimated at about 75 million blackbirds.

Evaluation of Bird Shield™ as a Blackbird Repellant in Sunflower Fields—In their quest to identify chemical repellants to lessen blackbird damage in the Great Plains, NWRC scientists selected 12 sunflower fields with bird activity and randomly assigned 6 fields for aerial application of 1 pint of Bird Shield (a registered blackbird repellant that contains methyl anthranilate) diluted in 5 gal of water. The other six fields served as untreated controls. Field crews observed blackbirds prior and subsequent to the aerial application of the repellant to determine its efficacy. The abundance of blackbirds in treated and untreated sunflower fields was not statistically different. The amount of damage (based on the area of seed missing from damaged sunflower heads within randomly selected plots) did not differ statistically between treated and untreated sunflower fields. Based on these field observations, the effectiveness of Bird Shield for repelling blackbirds in sunflower fields does not look promising.

Economics of Lethal Control To Manage Damage to Sunflower—In the northern Great Plains of the United States, conflicts between red-winged blackbirds and sunflower growers have intensified since the late 1960s with the expanded production of sunflower as a commercial crop. NWRC scientists and an APHIS economist examined the potential effects on blackbird populations of the removal of up to 2 million red-winged blackbirds annually under a 5-year program of baiting during spring with DRC–1339-treated rice. The researchers also examined whether lethal control, in combination with current levels of breeding-habitat management, would be cost effective in decreasing depredation of sunflower crops during late summer. They modeled the cost–benefit ratio for four culling scenarios involving (1) variable animal culls, not exceeding 2 million birds, with and without density compensation (i.e., a positive density-dependent response) on adult survival; and (2) culls of 2 million birds annually with and without density compensation.

The investigators constructed a red-winged blackbird population model that represented an age-based matrix, calibrated to stable growth. A population of 27 million birds on April 1, 2003, was assumed as representative of the total red-winged blackbird breeding population staging in eastern South Dakota and migrating into North Dakota. Under each culling scenario, the stable red-winged blackbird population (equally for females and males) was reduced and the population projected through September 2003 (week 23 of the annual cycle). The researchers than evaluated the associated costs of the management relative to potential sunflower crop losses, assuming $0.07 in damage per bird and 4-percent loss to other factors.

Variable annual culls, likely the more biologically realistic model scenarios, yielded mean annual removals of 1,240,560 birds with density compensation and 1,231,620 birds without density compensation, with cost–benefit ratios of 1:2 and 1:3, respectively. Annual intrinsic rates for the model population over the 5-year period ranged from –1.4 to –2.2 percent. Considering potential variability in the effectiveness of the cull and the combination of direct and indirect costs, scientists contend that the realized benefits to sunflower growers by lethal control of red-winged blackbirds via spring baiting, in combination with current nonlethal management efforts, would likely be negligible.

TITLE: Defining and Reducing Wildlife Hazards to Aviation

GOAL: Provide scientific foundation for Wildlife Services programs at airports throughout the United States to reduce wildlife hazards to the aviation industry.

To be certified for passenger traffic by the Federal Aviation Administration (FAA), most U.S. airports are required to have wildlife hazard-management plans in place. In addition, the FAA has strict standards regarding bird-strike capabilities of aircraft engines and the siting of wildlife attractants such as waste-management facilities near airports. An interagency agreement between NWRC and the FAA was established in 1991 to provide the FAA with scientific support for recommendations and policies to control wildlife hazards to the aviation industry. These wildlife hazards are primarily caused by federally protected bird species, although certain mammals such as deer can also be a problem. Research and information needs cover a broad spectrum of topics related to understanding the nature of wildlife hazards at airports, developing management tools that will reduce these hazards, and providing airport personnel with information on the latest strategies for controlling wildlife hazards.

Effectiveness of Birdblox™ as a Perching Deterrent—Birds perching on fences, signs, light fixtures, and ledges often pose a hazard at airports and other locations where birds are not desired. Reduction of perching sites should make airports less attractive to these species and thus reduce the risk of damaging bird strikes. A new antiperching device called Birdblox™ is a plastic form designed to fit over 2 × 4 lumber used in pole buildings and either physically block space or present a row of sharp points that have minimal surface area for perching. During 2002, brown-headed cowbirds, red-winged blackbirds, common grackles, European starlings, and rock doves were tested in an aviary where a desired perch was covered with Birdblox. Birds perched on Birdblox 0.1 percent of the time compared to 14 percent on untreated perches. In aviary tests, Birdblox was effective at keeping four species of common pest birds from perching on a desired perch and might provide a suitable perch deterrent for use in buildings at airports.

Development and Evaluation of a Pulsed Landing Light System To Reduce Bird Strikes to Aircraft—NWRC scientists evaluated a commercially produced, pulsed lighting system (Pulselite™) as an early warning system for preventing bird–aircraft strike hazards. This system was developed to increase the visibility of aircraft to air traffic controllers as well as pilots. Although it was not designed for bird-strike avoidance, some pilots reported a reduction in strikes and greater bird awareness when using the Pulselite system.

NWRC studies compared the reaction times of cowbirds, herring gulls, and mourning doves to landing lights with alternating versus continuous (standard on most aircraft) signals. The results indicate that landing lights and other external stimuli can influence avian behavior in response to an oncoming vehicle, but the effects of the lights varied within and between species.

Experimentation continued during fall 2002 and spring 2003 to investigate specific wavelengths and a range of pulse frequencies that might startle or stimulate avoidance behavior in rock doves. This work with the Pulselight system and light-emitting diodes (LEDs) in a fixed position caused test birds to exhibit alert behaviors. Between 91 percent and 99 percent of birds exposed to the 475-nm and 644-nm wavelengths pulsed at the rapid setting (approximately 24 Hz) exhibited an alert posture during testing. These results were in contrast to control birds, which exhibited alert behaviors less than 60 percent of the time. Further, with the exception of the red treatment, NWRC researchers' findings are consistent with peaks in the spectral sensitivity curves for cone visual pigments in the rock dove retina. Relative to longer wavelengths, birds exposed to treatments shorter than 475 nm were generally more alert at the slow (approximately 0.75 Hz) setting. However, because of the lack of standardization in intensity (photon flux) relative to other wavelengths, firm conclusions about both treatments at 370 nm cannot be drawn. However, these results may be indicative of the possible utility of both the 475-nm and 644-nm LEDs in eliciting an alert behavior in rock doves. Biologically, these findings are logical in that these birds likely use contrast in foraging and predator detection (e.g., long wavelengths against a UV-dominated sky).

Evaluation of Red-Tailed Hawk Relocation at Airports—Raptor translocation from airport environments is a management strategy that has been recommended and used by some airport operators attempting to reduce aircraft strikes. However, supportive data are lacking about the optimal distance and direction birds should be moved, as well as their return rates, posttranslocation fates, and the overall efficacy of the technique. NWRC biologists collaborated with Illinois WS personnel in a VHF and satellite telemetry study December 1999 through December 2002 to address these issues at an Ohio airport.

Of the 214 translocated red-tailed hawks, 22 were fitted with satellite and 12 with VHF transmitters. All birds were transported to 12 sites in Illinois and released 59 or 242 km from the airport. Only 3 percent of the juvenile birds returned, whereas 26 percent of the adults returned. No other factors significantly influenced which birds returned. About one-third of the adult birds appeared to be migrants and remained near the release site less than 6 days before continuing their migration.

A red-tailed hawk translocation program can be a costly, time consuming, and tedious approach to raptor management. Concentrating trapping efforts on juvenile and migratory individuals can maximize the capture rate while minimizing capture effort and the return rate.

Title: Emerging Technologies To Resolve Human–Wildlife Conflicts: Cell Culture, Repellants, Antisweet and Antinutrient Agents, and Behavioral Methods

GOAL: Discover new technologies and adapt existing methods for the development of nonlethal ways to resolve conflicts between humans and wildlife.

Despite considerable demand for nonlethal methods of wildlife damage management, few effective chemical repellants and selective attractants exist for most applications. Fundamental physiological data concerning olfaction, taste, and trigeminal chemoreceptive abilities of wildlife are largely nonexistent, and the application of existing behavioral data to enhance wildlife control technologies is lacking. This project investigates the chemosensory morphology, histology, and physiology of sensory system function in several wildlife species important to the WS program.

Avian Repellant Research—NWRC scientists in collaboration with researchers at Monell Chemical Senses Center have worked

to develop effective avian repellants that are safe to humans, animals and the environment. The sensory systems of birds differ greatly from those of mammals, so that some substances that are innocuous or even attractive to humans can be highly repellent to birds. This fact has led NWRC scientists to research plant-derived compounds used in the fragrance and flavor industries. Results have subsequently shown that many of these compounds are repellent to birds. Citronellyl acetate, for example, has a floral smell to humans and is used in everyday products such as deodorants but is highly repellent to birds. An NWRC scientist working at the Monell Chemical Senses Center has also discovered that garlic oil, a substance that most mammals find to be pleasant, is repellent to birds. Research that recognizes the sensory differences among species will ultimately result in more effective, species-specific repellants for reducing damage caused by birds.

MAMMAL RESEARCH PROGRAM

Title: Developing Tools and Strategies To Reduce Mammalian Impacts on Forest Resources

Goal: Provide feasible nonlethal solutions and improved rodenticides for forest managers to resolve problems encountered with selected wild mammals.

Foraging wildlife affects forest resources in numerous ways. Damage can result in reduced productivity, delayed harvest cycles, failure to replace trees after a harvest or a fire, or failure to establish native plants. Managing resource to resolve these problems is becoming increasingly difficult because the land base to produce timber is shrinking, reducing management options while increasing the necessity to protect remaining resources. There is a critical need for enhanced research to develop new nonlethal approaches and improve existing approaches.

Mountain Beaver Biology and Ecology—In the Pacific Northwest, mountain beavers cause more damage to tree seedlings and 10- to 15-year-old trees than any other mammal species. Efforts to manage mountain beaver damage are hindered by a lack of, or outdated information on, the species' basic biology. Researchers at NWRC's Olympia, WA, field station have designed and implemented several studies to increase the understanding of mountain beaver biology (i.e., reproduction, distribution, population characteristics, movements, and feeding behavior).

Information gathered from two studies with radio-collared mountain beavers has demonstrated that this species can move greater distances and use larger areas in its daily activities than previously recorded. For example, average home-range size for the mountain beaver was thought to be 0.03 to 0.2 ha. However, NWRC scientists have documented home-range sizes from 1.17 to 4.5 ha in some clearcut areas. In addition, dispersing animals can travel greater than 0.5 km. In both pen trials and in the field, available forage has an effect on both seedling damage and the distance that animals move. Center researchers have also determined that, with adequate forage, mountain beaver can reproduce at 1 year of age. This information has profound effects on how foresters manage timber to minimize mountain beaver impacts.

Assessment of Toxicants—Attempts to manage mountain beaver damage through repellants, barriers, and trapping are costly and not always successful. Trapping, the most reliable method to control beaver populations, is becoming both politically and socially less acceptable. Therefore, alternative tools besides traps to control mountain beaver populations are desirable. At present, there are no toxicants registered for aboveground mountain beaver control; however, four toxicants are registered for underground control of this species.

NWRC scientists have screened these toxicants and determined that chlorophacinone is a likely toxicant for aboveground mountain beaver control. After completing a study that is addressing the efficacy of pulse baiting for operational use, Center scientists plan to conduct a field evaluation, which, if successful, could provide a new tool for operational control of mountain beaver damage.

Title: Ecology, Behavior, and Management Methods for Predators To Protect Livestock and Wildlife Resources

Goal: Examine ecology, behavior, and management of predators in relation to depredations on livestock, game animals, and threatened and endangered species.

Data on predator population dynamics, ecology, and behavior in relation to predation patterns on species of human concern (mainly livestock, game species, and threatened and endangered species) are needed for effective depredation management. These data can also be used as a basis for developing accurate methodologies of indexing predator abundance and monitoring management programs. While much data exists, significant gaps remain with regard to predator–prey, predator–predator, and predator–livestock relationships. In addition, despite increasing interest in selective attractants for the delivery of pharmaceutical materials, repellants, and deterrent strategies that can reduce depredation, few practical alternatives exist.

Behavior of Alpha Coyotes Toward Sheep, Guard Animals, and Humans— Researchers at the NWRC Utah field station have initiated a study on a ranch near Woodruff, UT, to obtain real-time data on the movement patterns of territorial coyotes in relation to sheep, guard animals, and human disturbances within their territories. In 2003, four pairs of resident coyotes, one member of another resident pair, and three transient coyotes without territories were captured by helicopter and outfitted with geographic positioning system (GPS) collars designed to give locations every 20 minutes for 3 successive days per week for 10 weeks. To date, 23,635 locations have been received. Of these, about 17,000 locations are usable.

Preliminary evaluation of the data suggest that coyote pairs use space differentially in their territories, with both members of pairs found together in some locations but usually apart in others. The results of this study will develop the use of GPS technologies to permit investigation of coyotes involved in depredation, their response to control strategies, and the development of new, selective techniques that target just those coyotes responsible for damage.

Collaborations on Coyote and Pronghorn Research in Wyoming— An NWRC researcher working with a graduate student from Utah is studying pronghorn antelope decline in a multipredator ecosystem in Grand Teton National Park and the surrounding Jackson Hole valley. Pronghorn antelope have declined over the past decade, and this research attempts to address reasons for the decline and how wolf recolonization of the valley may affect interactions between coyotes and pronghorn. The research is being done in collaboration with the Wildlife Conservation Society, the USGS Biological Resources Division, and the National Park Service. Preliminary results suggest that coyotes kill a large proportion of fawns in areas where wolves are not present.

Title: Alternative Capture Systems and Aversive Stimulus Applications for Managing Predation

Goal: Identify, develop, and evaluate advanced capture systems and aversive stimuli applications for predation management emphasizing animal behavior and engineering approaches.

In Europe and the United States, large predators are returning to former habitats that now host people and livestock. Public and professional concern for animal welfare and a simultaneous requirement for a stable and affordable food supply have led to intense pressure on wildlife managers to find immediate solutions when humans and wildlife adversely interact. However, capture technologies are largely reliant on tools and materials developed hundreds and thousands of years ago. These older technologies are still widely used because extensive use has proven their effectiveness and few other options are commercially available. This project is attempting to develop new and alternative techniques to minimize adverse interactions between predators and livestock.

Effectiveness of a Movement-Activated Guard and Fladry Under Experimental Conditions—NWRC scientists have developed a motion-activated (MAG) frightening device that incorporates a high-intensity strobe and 30 randomly activated sounds, including yelling, approaching aircraft, and gunfire. During the winter of 2002–03, MAG and other scaring strategies including fladry (a method that involves hanging strips of flagging to create an apparent visual barrier) were tested in the vicinity of Gordon, WI, as deterrents for eagles, black bears, and wolves. Testing involved placing fresh deer carcasses in woodlot clearings and then deploying MAG or fladry as deterrents to scavenging. MAG deterred eagles, wolves, and bears. Fladry failed to deter any of these species from feeding on carcasses.

Title: Holistic Management of Rodents and Other Introduced Vertebrate Pest Species in Hawaii

Goal: Develop safer and more effective methods for reducing rat damage to Hawaiian agricultural crops.

Rats cause significant agricultural, natural resource, and human health impacts to the Hawaiian Islands. Current control techniques provide inconsistent levels of protection from rodent impacts. NWRC biologists conduct field and laboratory research to identify, evaluate, and improve methods, materials, and devices to reduce and monitor rodent impacts on Hawaiian crops and natural resources.

Rodenticides Research—Researchers at NWRC's Hawaii field station continued rodenticide development research, most recently related to the use of aerially delivered rodenticides for conservation purposes. Two rodenticides are currently registered for conservation purposes but can only be used in bait stations. In the more remote and difficult-to-access areas of the islands, the only practical method for controlling rat populations is through the use of aerial application. These remote areas are composed of native flora and fauna and are the few remaining homes of Hawaii's threatened or endangered forest species. The USFWS, in cooperation with the rodenticide registrants, is leading an effort to register two rodenticide products containing diphacinone, an anticoagulant, for aerial delivery. In support of that effort, NWRC scientists have conducted a series of studies designed to identify optimal application rates and assess nontarget impacts of aerial broadcast of diphacinone rodenticide baits.

The first experiment determined if tetracycline could be used as a biomarker to indicate whether a rat had been exposed to rodenticide bait. In this laboratory study, roof rats were exposed to a wax bait or a compressed grain bait treated with tetracycline. Following the exposure period, lab personnel then checked the animals' bones and teeth under black light for the presence of tetracycline fluorescence markers. Tetracycline proved to be an excellent oral biomarker that showed clearly under the ultraviolet light.

A subsequent field study monitored the rate at which rats removed placebo bait, treated with tetracycline, from forested habitats. This study was used to determine the optimal application rates for aerially delivered bait. Three rates were applied by hand broadcast, field crews monitored the pellets for presence and also pellet integrity. This study showed the best application rate to be 5.6 kg/0.40 ha.

It has been reported that slugs and snails sometimes feed on rodenticide bait boxes used in the field for rat control. NWRC scientists conducted a laboratory study to evaluate the impact of diphacinone on slugs and snails and also determine the rate at which gastropods accumulate diphacinone residues.

Two species of slugs and one species of snail were exposed to diphacinone bait. None of the animals died during the study. Residue analysis showed the species accumulated diphacinone at different rates but could survive with residues of up to 5 ppm, with average residues in the range of 2.5 ppm. These data will be key to determining risk to forest species that consume gastropods.

A major concern of the environmental community toward aerial baiting with rodenticides is the primary impact that baits could have on native birds. NWRC conducted a study that

consisted of both visual bird observation and animal-activated still photography over 76,800 hours to determine the species visiting bait pellets placed on the forest floor. Two formulations, wax and compressed grain pellets, were tested in four forest types. Bird counts identified 10 native bird species and 12 nonnative bird species in the vicinity of the bait monitoring stations. Wax and compressed grain baits were equally attractive to rodents. Rodents were documented in 99 percent of the 21,211 pictures taken containing vertebrates. Mongoose and cats were documented in 0.5 percent and 0.1 percent of the vertebrate photographs, respectively, and most frequently at wax baits. Nonnative birds were documented in 100 (0.5 percent) of photographs of vertebrates. Only the red-billed leothrix was observed eating the bait. No native birds were photographed at bait monitoring stations.

These data—along with data gathered in two broadcast application studies and other laboratory studies conducted on crows and geese—are being used to support the registration application of aerially delivered diphacinone rodenticides for conservation purposes. The data will be incorporated into a nontarget hazard assessment conducted by NWRC scientists in Fort Collins. The results of this and other work have shown that aerial baiting with diphacinone-based rodenticides presents little risk to birds.

Invasive Frog Research—During the past 2 to 3 years, NWRC's Hawaii field station has focused some of its research efforts on the control of two Caribbean frog species, the Coqui frog and the greenhouse frog, that have recently invaded the Hawaiian Islands. The frogs' arrival in Hawaii is assumed to have been through accidental transport from their native range via contaminated plant materials from Florida. Intrastate transport of plants is also believed to be spreading these frogs throughout the main Hawaiian Islands. Currently, the Coqui frog is known to exist on Hawaii, Maui, Oahu, and Kauai. Control of the frogs is a priority for Hawaiian Department of Agriculture and State and Federal conservation agencies for three reasons: the frogs are a potential threat to Hawaii's fragile native fauna because of increased competition for invertebrate prey and impacts on native invertebrates; they are a threat to the commercial flower business because buyers have begun to refuse to purchase plant material from nurseries know to contain either frog; and their evening calls are very loud. Resort owners and people residing near Coqui populations are complaining about the noise.

In response to the growing need to control frog populations, NWRC's Hilo scientists began a series of studies that evaluated more than 70 chemical compounds (registered pesticides, herbicides, and pharmaceuticals) that could be used as dermal toxicants to eradicate the frogs. Through the course of these evaluations, two compounds— caffeine and citric acid—were identified as effective dermal toxicants that could be applied as a spray under field conditions. For a number of reasons, the Center's current research emphasis is on citric acid.

Only one population of Coqui frogs has been reported on the island of Kauai. This population has about 100 males and inhabits less than 3 acres in a single isolated gulch. With a goal of eradicating the frog from this gulch in 2003, Center scientists designed a study to use citric acid to treat the occupied habitat, identify the nontarget hazards to vertebrate and invertebrate organisms, and determine the effect of runoff from the site on a small reservoir located just below the treatment area. During one night, personnel from NWRC, Hawaii WS, the Hawaii Department of Agriculture, the Hawaii Department of Land and Natural Resources, the Hawaii Agriculture Extension Service, and the Kauai Invasive Species Committee sprayed the site with nearly 1,200 gal of 16-percent citric acid solution. This treatment reduced the population of calling males to seven or eight animals. Monitoring data showed little impact on treated nontarget vertebrates and invertebrates, with the exception of introduced cane toads. The gulch will continue to be monitored for the presence of calling males. Continued spot treatments should eventually lead to the eradication of the Coqui frog on Kauai. This study demonstrated that citric acid could be used to control large populations of Coqui frogs with little impact on the treated environment.

PRODUCT DEVELOPMENT RESEARCH

TITLE: Development of Chemistry-Based Tools for Wildlife Damage Management

GOAL: Develop chemistry-based techniques and tools that fulfill the research needs of Wildlife Services.

The approach to developing chemistry-based tools is based on increasing the understanding of the chemical and biochemical aspects of wildlife damage. Analytical chemistry forms the foundation of much of the research conducted under this project. Project scientists have experience in related scientific disciplines, such as metabolism chemistry, environmental fate, chemical synthesis, toxicology, chemical ecology, wildlife genetics, and chemical formulation. Project personnel also initiate and/or collaborate with other NWRC scientists on a variety of studies that contribute to development of wildlife management tools.

Genetic Analysis of Saliva on Predation Wounds—Samples taken from predation wounds can provide valuable information about predators because such wounds potentially contain DNA from both the prey (in blood from the wound) and predator (in saliva left on the wound). NWRC genetics researchers used molecular genetic methods to identify the species, sex, and individual genotype of predators by analyzing saliva on predation wounds. These genetic methods allowed the differentiation of felids from canids, and the identification of canid predators to the species level.

Center scientists have also developed laboratory methods to assess coyote sex in the presence of potentially interfering sheep DNA. In most saliva samples analyzed from predation wounds on sheep over the past 2 years, the genetic data confirmed coyote predation. Additionally, in the majority of cases, male coyote DNA was detected. Genetic identification of the individual coyote responsible for the predation was possible from some samples. This is the first research using molecular genetics to identify predators from predation wound samples.

These methods could prove very useful in areas where more than one canid species attack livestock, or in areas where reintroduced canids (e.g., wolves) are being monitored. Additionally, genetic analyses provides a method to verify that field identification of predator species is accurate. One caveat of this DNA forensics work is that, in order to obtain information on the predator, predation wounds must be differentiated from wounds left after scavenging.

TITLE: Research on Improved Assessment, Sampling, and Economic Methods for Wildlife Damage Management

GOAL: Develop and validate new techniques to assess, sample, and quantify wildlife damage management, plus determine related benefits and costs.

This research project is attempting to quantify benefits and costs of both traditional and new wildlife management activities, such as intervening with repellants, relocations, removals, and rodenticides to limit the adverse effects of wildlife on agriculture, natural resources, and human health and safety.

Predation Management and the Endangered California Least Tern— The California least tern is one of the original listed endangered species. Key nest sites for this species remain at Camp Pendleton, CA, where about 17 percent of the U.S. nesting population resides. NWRC researchers have been collaborating with WS and San Diego Zoological Society personnel in assessing the role of predation management and reproduction monitoring in the long-term recovery of this bird. Extensive predation management to create a predator-free zone around this nesting area has been practiced at Camp Pendleton since 1988. Analysis of long-term data showed that tern reproduction was erratic between 1971 and 1987 but steadily increased during the period 1988–2002. Breeding pairs ranged between 137 to 300 and 175 to 1,029, during these periods, respectively.

In 2003, an economic analysis of fixed-cost budgets for predator removal and reproduction monitoring activities to protect the endangered California least tern at Camp Pendleton was completed. This ex post study covered monetary outlays between 1995 and 2001. Reproduction monitoring was provided by staff of the Zoological Society of San Diego, and predator removal was provided by WS California.

In separate regression analyses, 15 biological, economic, and meteorological variables were used as predictors of 4 tern production variables (nests, eggs, fledglings, and adults). Mean net current annual monitoring and predator budgets for these 6 years were $80,115 and $78,178, respectively. For purposes of analysis, annual fiscal data were converted to "proxy" variables of hourly labor costs ($/h). More time was spent in monitoring (3.12 h/day) than in predator-removal (6.96 h/day) activities. Expenditures for staff hours devoted to both reproduction monitoring and predator removal were associated with greater counts of tern eggs and adult birds. Interestingly, no meteorological variables predicted any of the dependent variables. Cumulative expenditures of >$1.04 million (net current value) during the 6-year period were associated with an estimated tripling of adult terns at the site.

These results are part of a growing body of literature that shows predator removal, where it is effectively practiced, pays dividends in higher numbers and production of endangered animals. Forecast analysis showed that increasing the nest-monitoring budget by 25 percent most noticeably increased the future production of total nests (by 106 percent) and fledglings (by 39 percent). Increasing the predator-removal budget by 25 percent had the greatest effect on the future production of eggs (increased by 10 percent). Finally, increasing both monitoring hours and predator-removal budgets simultaneously had the greatest influence on forecasting the future number of adults. This type of analysis will be used to guide the efficient use of resources toward the preservation of the least tern.

Predator Management of Coyotes To Improve Antelope Recruitment in Wyoming—Predation management of coyotes to improve fawn survival of both mule deer and pronghorn antelope has only sometimes been successful. The Wyoming Fish and Game Department has determined that the value of a pronghorn analyzed from its contribution to the local economy is $3,000, while civil penalties for an illegal antelope take can range from $400 to $10,000. Using a range of values for one antelope ($400, $1,500, $3000, $10,000), NWRC researchers determined that the benefit:cost ratios for the number of antelope saved by predator management were between 15:1 and 541:1. The results of this benefit–cost analysis demonstrate that management of coyote predation on antelope has the potential to benefit Wyoming between $178,000 and $4,450,000 annually, depending on the dollar value ascribed to each fawn.

Integration of Predator Monitoring and Removal Results in Reduced Sea Turtle Nest Predation—Since the use of a passive tracking index methodology was first incorporated into predator management methods in 2000 at Hobe Sound National Wildlife Refuge, the efficacy and efficiency of control efforts have improved considerably. In 2000, the nest predation rate by raccoons and armadillos dropped to 28 percent from 42 percent the year before predator monitoring was applied. In 2002, after a further 2 years of integrating monitoring with removal, nest predation dropped to 9 percent, the lowest ever recorded. An economic analysis for the 1,238 turtle nests deposited in 2002 showed that the value of the additional resource of hatchlings produced over historical high predation rates was $6.9 million. The economic benefit over the predation rate from the last year of control without using predator monitoring was $2.6 million. The cost for the control agreement was only $8,000.

TITLE: Development of an Avian Infertility Tool for Application in Goose Management

GOAL: Test the effectiveness and develop for use the contraceptive nicarbazin for reproductive control of geese.

As goose populations and urban areas expand and overlap, Canada geese are more often considered a nuisance and potential health problem at sites like airports, golf courses, industrial parks, government sites, and city parks. As a result, the public increasingly wants resident goose populations managed. It appears that a drug given to poultry may be useful in suppressing the reproduction success of wild geese. Nicarbazin is a chemical traditionally used in broiler chickens to prevent the disease coccidiosis. One side effect of this treatment is decreased egg production coupled with decreased hatchability. It appears that nicarbazin causes reduced hatchability by breaking down the membrane surrounding the yolk, creating conditions under which the embryo cannot develop. NWRC scientists are trying to determine if this very undesirable side effect in laying chickens might become a big plus in reducing nuisance populations of Canada geese. In partnership with Phibro Animal Health, Inc., NWRC is attempting to take advantage of this effect and develop a feed-type product to suppress reproduction in nonmigratory Canada geese.

Nicarbazin Bait Assessment—NWRC scientists have conducted studies on a variety of baits containing nicarbazin to assess its absorption into the bloodstream and ultimately

its contraceptive efficacy. One promising product, OvoControl 800™, is similar to the product Ovistop™, which is currently registered in Italy as a pigeon contraceptive. OvoControl 800 is bait that consists of whole-grain corn overcoated with 800 ppm nicarbazin and sealed with a waxy coating. Phibro Animal Health has obtained exclusive rights to the U.S. market for both Ovistop and OvoControl 800.

To study the absorption of nicarbazin from OvoControl 800, NWRC scientists captured wild resident Canada geese using the drug alpha-chloralose. Once in captivity, the geese were fed OvoControl 800 and nicarbazin levels were analyzed in blood samples. Results from these laboratory pen studies indicate that absorption of nicarbazin from OvoControl 800 would be adequate to provide contraceptive effect in the field. Based on these results, OvoControl 800 has been selected for further development as an FDA-registered product to reduce hatchability of eggs laid by resident Canada geese.

Field Evaluation of Nicarbazin—In the spring of 2004, scientists at the NWRC will be working in cooperation with Oregon WS and Phibro Animal Health to plan and conduct an extensive field study to test the effectiveness of OvoControl 800, in reducing the reproduction of the resident Canada geese in Oregon. Oregon WS receives a high volume of requests to help resolve goose problems. During 2003, with Oregon WS assistance, 12 potential study sites were identified within the State. Interested stakeholders, including members of local chapters of the Audubon Society, were provided with information about the environmental safety of nicarbazin and its effects on human health. In preparation for the 2004 field study, all potential sites were monitored for nesting activity during 2003. Nest locations were identified and recorded with GPS equipment to create detailed GIS maps of each site showing individual nest locations. These maps will be used to select optimal test locations and potential bait stations within each site and will permit more proficient monitoring of nests during the study in 2004.

Title: Development and Evaluation of Rodent Damage Management Methods, With Emphasis on Repellants, Barriers, and Attractants

Goal: Develop new and improved repellant and barrier strategies for damage caused by voles, pocket gophers, rats, and ground squirrels to agricultural crops and property.

Many small-rodent species cause substantial damage to grains, forage crops, reforestation areas, livestock feeds, property, and other resources. While rodenticides and traps are still heavily relied upon for the control of rodent populations, NWRC researchers are attempting to find new or improved approaches to reduce rodent damage. These studies include evaluations of repellants, barriers, frightening devices, biological control, and cultural methods. Researchers also are providing data to maintain, or obtain new, registrations on rodenticides.

Monitoring Cuban Hutia at Guantanamo Bay, Cuba—The Cuban hutia is a large rodent native to Cuba. While the species is rare in most parts of the island, it is very common at the U.S. naval base at Guantanamo Bay. Conflicts with humans include damage to landscaping, gnawing through cables, damage to vehicles, and large accumulations of feces in residential areas. Additionally, hutia are primarily herbivores, and botanists have documented substantial damage to native vegetation with little subsequent regeneration of many plant species. A visit in 2002 by an NWRC scientist from Fort Collins documented that hutia are quite prolific and able to exploit most habitats and foods. While several methods of control have been considered, current management has focused on shooting and trapping followed by euthanasia or relocation to remote areas.

Appropriate management of hutia requires effective methods to monitor populations. During June 2003, two NWRC scientists visited the U.S. naval base to test some potential monitoring methods. Both tracking tiles (printer's ink on linoleum squares) and a nontoxic chew block (oatmeal in paraffin wax) were successful in documenting visits by hutia. The animals were also readily live-trapped in cage traps baited with fruit and vegetables. In 5 days of trapping, the overall capture rate was 51 percent (46 captures in 90 trap-nights). All captured hutia were marked before release at their place of capture. There were eight recaptures during trapping days 2–5, suggesting that the animals do not become trap-shy. Consequently, mark–recapture may be another method that can be used to monitor hutia populations if hutia densities can be determined.

In a subsequent trip in August 2003, NWRC researchers determined that there were higher numbers of hutia in more remote locations than in developed areas where more population control has been implemented.

Title: Field Evaluation of Chemical Methods for Brown Treesnake Management

Goal: Develop techniques to help control BTSs on Guam and prevent their dispersal from that island.

The BTS, a species accidentally introduced to the island of Guam, has decimated that island's native fauna and poses a similar threat to other Pacific island ecosystems. NWRC scientists are field-testing chemical methods to control the BTS, including toxicants, attractants, repellants, fumigants, and reproductive inhibitors. The eventual goal of this research is to implement their use in an integrated program to control the BTS on Guam, prevent its dispersal from Guam, and control snake populations, when necessary, in other island situations by a variety of individuals and organizations, including WS, the Department of Defense, the Government of Guam, natural resource managers, military personnel, and others.

Field Evaluation of Beef as a Bait— Presently, mice are used in two operational phases of the BTS control program on Guam: dead neonatal mice (DNM) are used as the matrix and lure as part of a toxicant delivery system, and live mice are used as the lure for capturing snakes in live traps. Because of logistic difficulties in getting mice to Guam, NWRC scientists are continuing to search for alternate matrices and lures that may be more readily available. Beef was selected for testing as a bait because it is commercially available on Guam and less expensive than DNM. (One beef bait costs about $0.03 compared to $0.62 for one DNM bait, and many baits may be required for large-scale operational control.)

BTS consumption (bait-take) of DNM and beef baits treated with pyrethrins were tested under both laboratory and field conditions on Guam. In the laboratory, bait-take of untreated and pyrethrin-treated dead mice was 90 percent and 100 percent, respectively; bait-take of untreated and pyrethrin-treated beef was 80 percent and 70 percent, respectively. Under field conditions, bait-take of untreated and pyrethrin-treated mice was 100 percent and 87 percent, respectively; bait-take of untreated and pyrethrin-treated beef was 27 percent each. Fewer ants and flies were observed on the treated baits in the field, but irrespective of the pyrethrin treatment, consumption was the same for each type of bait.

These data indicate that it is not necessary to treat baits with insecticides and that unadulterated beef baits are not as acceptable as DNM baits under field conditions. Additional research will be needed to make the beef bait as acceptable as the DNM.

Evaluations of Snap Traps To Capture BTSs—Live-trapping and hand-capture by spotlight searches of fencelines and forest vegetation are methods currently used for detecting and controlling BTSs in their natural habitat. But both methodologies have disadvantages: live traps are expensive and require the maintenance of live mice as lures; and spotlight searches, especially in the forest, require a high degree of personnel training. Because snakes are also attracted to DNM in bait stations, NWRC researchers hypothesized that snakes would probably also be attracted to, and attempt to take, DNM from snap traps; and snap traps are much less expensive than live traps. Therefore, NWRC researchers compared the capture efficiency of two types of snap traps baited with DNM to the capture of snakes with live traps and to the take of DNM from bait stations in field evaluations on Guam. Fifty-five percent of the live traps captured snakes, and a number of these traps caught multiple snakes. The efficacy of snap-trapping depends on what the traps are made of. Thirty-eight percent of snap traps having a wood base and metal trigger captured snakes, compared to 47 percent with "quick set" snap traps manufactured from plastic and metal. Bait-take from bait stations was 72 percent. These results are encouraging but additional snap-trap developmental work is needed to increase the efficacy to that of live traps.

Snake Repellant Patent Approved—In early September 2003, the U.S. Patent office approved an NWRC patent application for snake repellants. Two NWRC scientists are listed as inventors on the patent. Among the repellants covered are a series of natural essential oils such as cinnamon oil and eucalyptus oil. This patent resulted from the Center's efforts to develop chemical control agents for the invasive BTS on Guam. Two methods of applying the repellants are described: vaporization of the active agent to saturate atmospheres in enclosed spaces and direct aerosol application. In both cases, the repellants promote vigorous escape behavior by snakes. A downloadable copy of a WS Technical Note on the use of the snake repellants is available from the NWRC library.

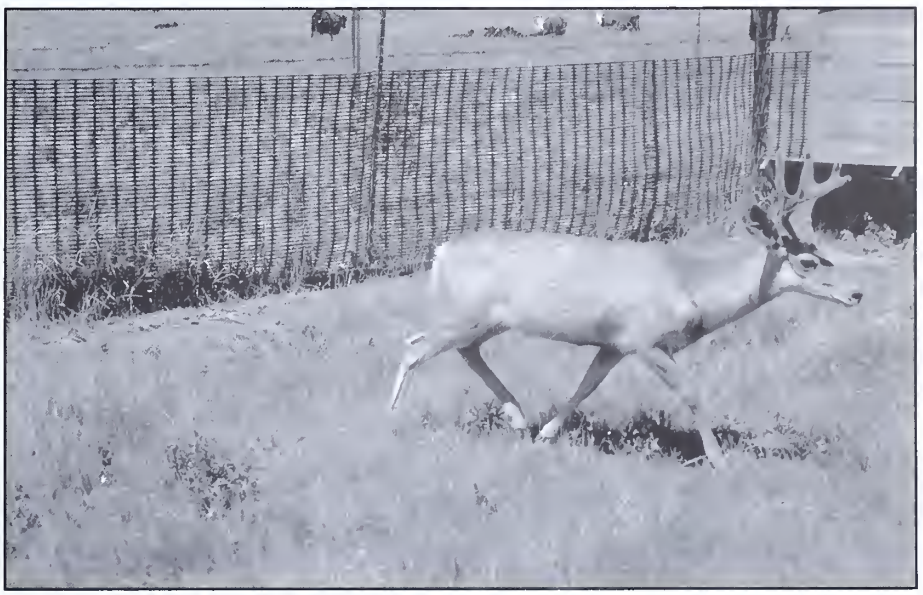
WILDLIFE DISEASE RESEARCH PROGRAM

Increasing human populations means greater encroachment of people into wildlife habitats. That, in turn, leads to increased contact between wildlife and people and between wildlife and domestic animals. Elevated contact can escalate the potential invasiveness of new diseases threatening human, domestic animal, and wildlife health. Additionally, heightened worldwide mobility of people, animals, goods, services, and products can move new disease organisms and their hosts thousands of miles in as little as a single day. Recent zoonotic diseases such as West Nile virus, wildlife rabies, hantavirus, and Lyme disease have resulted in a growing disease risk to humans, while other diseases such as scours in dairy cattle, bovine tuberculosis, brucellosis, avian influenza, and pseudorabies negatively impact livestock. NWRC is conducting research to develop applied methods to (1) mitigate and manage wildlife diseases such as raccoon and skunk rabies and bovine tuberculosis and (2) control West Nile virus, bacteria found in urban geese and blackbirds associated with dairies, and other pathogens that may cross from wildlife reservoirs to humans. Research is focused on development of surveillance and monitoring techniques, as well as effective, safe, and deliverable vaccines, barriers, and other methods to reduce or eliminate disease transmission.

Title: Controlling Wildlife Vectors of Bovine Tuberculosis and Rabies

Goal: To study the ecology of wildlife diseases, assess the risk of disease transmission among wildlife, domestic animals, and humans, and develop methods that reduce or eliminate such transmission.

Surveillance for Bovine Tuberculosis in Wildlife and the Environment in Northern Michigan—In 2002, research scientists from NWRC in Fort Collins initiated surveillance research on the wildlife hosts and environmental contamination of bovine tuberculosis (TB) in an outbreak area in northern Michigan. TB infection has shown up in animals on at least 30 farms since the outbreak began in 1998. Samples from 702 animals of 31 species have been processed and submitted to the Michigan State University (MSU) diagnostic laboratory. As of summer 2003, lab results of 575 cultured samples had been completed: two opossums were positive for *Mycobacterium bovis* and two for *M. avium*. About 50 raccoons also were collected in the



core area and turned in to the Michigan Department of Natural Resources (DNR) for processing. Four of those were positive for *M. bovis*. Other suspect animals, with final tests pending, include a deer mouse, two porcupines, and a cottontail rabbit. Wildlife sampling was initially conducted throughout the core area of the outbreak but now is focusing on newly infected cattle farms. NWRC scientists are also working with MSU to investigate possible environmental sources (e.g., soil, water, vegetation, animal feed, animal feces) of bovine TB.

An NWRC scientist is on the graduate committee of a Ph.D. student who has developed the necessary field and laboratory protocols to conduct environmental sampling for bovine TB. The student has been able to greatly reduce the problem of bacterial and fungal contamination of samples by using the CB–18 TB Culture Kit with lytic Decon II (Integrated Research Technology, LLC) method versus the traditional NaOH/NaCl method. The student has also collected and processed small numbers of environmental samples from eight farms.

While acid-fast bacteria were cultured from several farms, no *M. bovis* has been detected. Intensive sampling will continue as new farms become infected, and there are plans to sample "environmental hot spots" such as deer wintering yards and deer feeding sites. This research is funded by APHIS' Veterinary Services program and is being conducted in collaboration with Michigan WS and MSU.

Oral Rabies Vaccination Program (ORVP) for Wildlife—Scientists from NWRC Fort Collins are conducting a variety of research studies designed to improve the efficacy of rabies vaccines in raccoons and skunks. Controlled experiments on captive skunks and raccoons are being conducted at the NWRC Outdoor Animal Research Facility in Fort Collins. These studies are focusing on development of baits and biomarkers for delivery of oral vaccines to wildlife, the efficacy of the rabies vaccines in raccoons and skunks, and the biosafety of the vaccine for nontarget species. Controlled field experiments that are examining the environmental persistence of vaccines, the rates of acceptance of target and nontarget species, and the interaction of target species population and baiting densities on vaccination rates are underway at NWRC's Ohio field station. This research, which is being conducted in collaboration with The Ohio State University, is evaluating important population and environmental variables on vaccination rates in a semicontrolled environment. Information gained in these studies is important for integrating data collected in fully controlled captive studies and large-scale field experiments.

Field experiments are designed to provide critical information on the zoogeography of raccoon and skunks in relation to ORVPs, and to design biologically and economically efficient operational strategies. A study being completed in conjunction with the Pennsylvania WS program has evaluated the delivery of various bait densities as it affects the vaccination rates of raccoons. Research being conducted in collaboration with several universities is documenting the movements, habitat-use patterns, and denning characteristics of raccoons and skunks. These studies will provide valuable information on the natural history of the target species, thereby providing for the most efficient timing and distribution of oral rabies vaccines.

Collectively, the research being conducted by NWRC represents the most comprehensive effort to develop biologically and economically efficient strategies for elimination of rabies in raccoons and skunks.

Canada Goose Disease Research—
The increasing use of public lawns by resident and migratory Canada geese and the increase in fecal contamination of those lawns has raised concern that geese may contribute to human health risks. Previous NWRC research has shown that Canada geese are carriers of bacterial pathogens associated with human illness. As a result, an issue of interest is the movement of these geese across landscapes because that movement can provide information about the sources of bacterial contamination of feces.

During the fall of 2002 and spring of 2003, field crews tracked Canada geese in southeastern Pennsylvania using radio collars and high-visibility neck collars. Marked resident geese stayed within about a 20-mile radius of their original capture site. However, given the high population densities and complex land development in the Eastern United States, the types of habitats geese used were diverse. For example, an individual goose was tracked to cattle pastures, college campus lawns, a reservoir, corn stubble fields, and a park. Another goose was found to visit a retirement home lawn, an amusement park, a city park, and local dairy pastures. These movements were sometimes within the same day.

These examples illustrate that geese visit a variety of landscape types, and people using those landscapes are exposed not only to bacterial populations characteristic of local environment but to bacteria from other environments as well. The types of bacteria found in environmental and fecal samples generally reflect the pathogen set found in previous studies—pathogenic *E. coli, Campylobacter,* and *Listeria.* In some cases, human hemorrhagic forms of bacteria were found.

Although quantifying the exact level of human health risk is not possible at the present time, the microbiological and movement data indicate that contamination of a site (e.g., a public park) may begin offsite. Thus, management decisions regarding resident geese need to consider landscape-level use patterns by geese as well as the various sites' potential as sources of bacterial contamination. For instance, goose control activities near a cattle pasture may be more easily justified than control of geese living in dry, sandy areas near the beach. From an agricultural perspective, the movement data suggest that geese may visit multiple farm sites, thus providing potential for transport of pathogens from one farm to another.

PROGRAM SUPPORT

Registration Highlights

Registration Status of APHIS Vertebrate Pesticides—In conjunction with APHIS' Environmental Services staff in Riverdale, MD, the NWRC Registration Unit is responsible for coordinating the development of data required for maintaining or modifying authorized uses of APHIS vertebrate-control products to meet the varied demands involved in protecting agriculture, endangered species, and public health. To meet this responsibility, the NWRC Registration Unit works closely with scientists to ensure that research results will be acceptable for regulatory purposes and that study designs meet EPA and FDA regulatory guidelines. In addition, the Registration Unit responds to requests from field personnel for new products or changes to existing products that will improve their ability to manage problem wildlife. Technical assistance and information are provided to State WS personnel, Federal and State agricultural and conservation agencies, as well as nongovernment individuals and groups.

APHIS vertebrate control agents are typically products that have minor use and, therefore, are not registered by private companies but are important tools for managing wildlife problems. APHIS currently holds registrations for eight active ingredients used in vertebrate-control products. These active ingredients are formulated into 19 unique Federal registrations. Currently registered products include an avicide (DRC–1339), an avian repellant (methiocarb), two rodenticides (strychnine and zinc phosphide), a fumigant (two sizes of gas cartridges that contain carbon and sodium nitrate), and two predacides (compound 1080 for use in the Livestock Protection Collar and sodium cyanide for use in the M–44).

DRC–1339—DRC–1339 is the only currently registered avicide in the United States. APHIS maintains registrations for five products containing DRC–1339. The five products include uses for blackbirds and starlings, pigeons, gulls, and corvids (crows, ravens, and magpies). Use-sites include feedlots and staging areas, structures, landfills, livestock birthing areas, and habitats of threatened or endangered species. In fiscal year (FY) 2003, APHIS received notices of reregistration from EPA for all five of its end-use products. EPA also approved the plantback intervals requested by APHIS (the interval required between applying bait to the ground and planting a crop) of 15 days for rice, wheat, corn, and barley, 30 days for sunflower and soybeans, and 365 days for other crops. In addition, APHIS either applied for or received approval for four State 1339 labels, primarily for corvids to protect human health or apple and pecan orchards from damage.

M–44—The M–44 is used to protect livestock and endangered species from predation by canids. During 2003, APHIS submitted a registration application to the state of Texas which would allow the use of the M–44 for coyote control to protect nonthreatened or endangered species.

Acetaminophen—An important accomplishment for the NWRC Registration Unit and the WS program during FY 2003 was receiving approval from the EPA for the registration of acetaminophen to control the BTS on Guam and the Northern Mariana Islands. This registration allows the use of acetaminophen-treated baits for conservation purposes in bait stations or by hand and aerial broadcast in uninhabited forests and cliff lines, where the maintenance of bait stations is impractical. This registration provides an important new tool for control of the BTS.

FDA Wildlife Drug Authorizations—APHIS has five Investigational New Animal Drug (INAD) authorizations with the FDA that allow interstate transport of the compounds for experimental purposes. Three of the compounds—gonadotropin-releasing hormone (GnRH) vaccine, porcine zona pellucida (PZP) vaccine, and 20,25–diazacholestrol (Diazacon)—are being tested as wildlife contraceptives. The other two compounds, alpha–chloralose and propiopromazine hydrochloride, are immobilizing agents. All of these products are for use by USDA personnel or persons under their direct supervision.

Two of the INADs are for immunocontraceptive vaccines containing GnRH and PZP. Research is underway to develop a dart-delivered single-shot contraception vaccine that would be effective for multiple years. The current focus of registration activities on PZP and GnRH involves locating a private company to enter into a partnership to develop and market the vaccines.

Regulatory Assistance Provided to Federal, State, and Nongovernment Organizations—WS program personnel or other cooperators from inside or outside the government often contact the NWRC Registration Unit for information when preparing Environmental Assessments, Environmental Impact Statements, and Section 7 consultations with the USFWS. NWRC is the primary supplier of these data to the WS program and its cooperators. Often responses to these inquiries entail preparing unique summaries and interpretations of NWRC research. NWRC personnel are also providing technical assistance to a consortium of State, Federal, and nongovernmental organizations in Hawaii that is developing a registration package and risk assessment for registering diphacinone as an aerially delivered anticoagulant rodenticide to control rats in conservation areas. These efforts are designed to lower rat populations and reduce rat predation on endemic birds.

PROVIDING WILDLIFE SERVICES

Goal: Provide high-quality wildlife damage management services for our customers that result in the protection of agriculture, wildlife and other natural resources, property, and human health and safety.

NATIONAL SUPPORT

Evaluation of Device for Trap Tranquilizer—NWRC coordinated a study with WS personnel in Minnesota, Guam, Idaho, and Utah that evaluated a polyethylene reservoir fabricated at the Pocatello Supply Depot as a potential cost-saving replacement for the McBride rubber device that is used as a Tranquilizer Trap Device (TTD). The polyethylene devices, also called pipette TTDs, were formulated with 0.6 g of propiopromazine hydrochloride (PPZH) and 0.4 g of ascorbic acid, an antioxidant. This formulation is also used in the McBride device. The targeted animals were gray wolves in Minnesota, feral dogs in Guam, and coyotes in Idaho and Utah. Varying degrees of tranquilization ranging from quietness and lack of attention to sleepiness were observed in the animals. Tranquilization effects observed in wolves, feral dogs, and coyotes were 69 percent, 75 percent, and 90 percent, respectively. A major drawback of the pipette TTD was leakage at the stem attachment to the trap jaw, and additional research will be needed to correct this problem.

Feral Swine Impacts on an Endangered Ecosystem in Florida—Feral swine roam the Savannas Preserve State Park in Florida. This park supports myriad threatened and endangered plants and animals and includes the last segments of "basin marsh" ecosystem in the State. Sampling surveys showed that 19 percent of remaining marsh had received damage by feral swine. Using habitat reclamation valuations, it was estimated that this damage had an economic value of over $1 million. The survey was instrumental in establishment of a feral swine removal agreement between the park and Florida WS. Monitoring of basin marsh recovery will occur as swine are removed.

Nutria Control in Louisiana—In June 2003, NWRC scientists from Olympia, WA, Starkville, MS, and Fort Collins, CO, assisted Louisiana Department of Wildlife and Fisheries (LDWF) personnel in field and laboratory investigations of zinc phosphide baiting as a control strategy for nutria in coastal wetlands. Using 4 airboats, trappers captured 54 nutria and transported them to LDWF holding facilities where potential baits and attractants are being evaluated by a team of NWRC biologists and Louisiana and Mississippi WS operational personnel.

According to the LDWF, habitat destruction by nutria is decreasing fresh, brackish, and salt-marsh waters, commercial and sport fisheries production, wetlands available to buffer storm surge, and habitat for other species of wildlife. LDWF believes that without a long-term plan to reduce the number of nutria and their impacts, there will be little chance of restoring coastal marshes in Louisiana.

GIS and GPS Training—In July 2003, a wildlife biologist from NWRC's North Dakota field station trained North and South Dakota WS operations employees on the use of handheld GIS and GPS devices. The interfacing of these two technologies allows for documentation, interpretation, and dissemination of geospatial data that are useful to field personnel and administrators alike. Potential applications include determination of locations of traps, trap types, days on which traps were set, number and species of animals or birds captured, topography of the surrounding trap sites, and the locations and phone/address contacts of the nearest farms and surrounding rural communities. All these data may be saved in transmittable files or printed as maps to be shared among all interested parties.

Repellant for Blackbirds in Rice Tested—During July and August 2003, NWRC scientists in Fort Collins evaluated Aza-Direct® for repelling blackbirds from eating rice seeds. The active ingredient is azadirachtin, a biological insecticide currently registered with the EPA. The repellant was applied to rice seed at concentrations varying from 0.5 percent to 2.8 percent. Relative to baseline (pretreatment) rice consumption, blackbirds ate 5 percent to 25 percent less of the treated rice over the 4-day, no-choice test. NWRC scientists are cooperating with several chemical companies to evaluate other potential chemical compounds as possible repellants for protecting rice from bird damage.

National Study of Mourning Dove Populations—During late August 2003, biologists from NWRC's Mississippi field station assisted biologists from the Mississippi Department of Wildlife, Fisheries and Parks (MDWFP) by providing logistical support for a national study of mourning dove population dynamics. MDWFP personnel banded 1,071 doves statewide, of which 115, or more than 10 percent, were banded at the NWRC field station. The mourning dove study is coordinated by the USFWS with the cooperation of MDWFP and wildlife agencies from 25 other States. This cooperative study was initiated to provide more reliable data on survival of mourning doves and estimates of harvest during the hunting season. Despite the importance of mourning doves as a game species, these data have not been collected on a large scale in more than 30 years.

INTERNATIONAL COOPERATION

Investigating the Rodent–Leptospirosis Connection in the Portuguese Azores— The Azores are Portuguese islands in the North Atlantic Ocean. The local culture is agrarian, and the Azores support a significant dairy cattle industry. Unfortunately, the islands have chronic leptospirosis situation that results in an average of 14 human cases per year and 1–2 fatalities. The cycle of this infectious bacteria in the ecosystem appears to involve introduced rats and mice that shed the bacteria in their urine and other bodily excretions, resulting in the infection of livestock, and subsequently, humans. Prevalence rates as high as 88 percent have been found on rodents from some of the islands. Prevalence rates in cattle are typically 30–40 percent. The role of other introduced wildlife and companion animals (European rabbits, feral cats, dogs, ferrets, weasels) in the epidemiology of the disease is not clear, although some seropositive hedgehogs were found. A cattle vaccine for leptospirosis exists, but because of the cost very few farmers use it. Warfarin and bromadiolone have been used to control rodents in the Azores.

An NWRC research scientist who had visited the Azores in 1998 was invited back in May 2003 as part of a technical working group of the Azores Cooperative Initiatives Program. The scientist provided input on rodent management in the Azores and evaluated research proposals submitted by Portuguese agency and university personnel aimed at controlling rodents and reducing the leptospirosis hazard to livestock and humans. Based on these proposals, it appears that efforts may be initiated to systematically study the ecology of rodents in the Azores and to test control methods. Acting on a recommendation of the NWRC scientist during the 1998 visit, the Azores Division of Veterinary Services has recently hired and trained a rodent biologist.

Monitoring Wildlife in Ethiopia— An NWRC biologist has developed a method for indexing wildlife populations that provides indices with valid quantitative properties. One index method fitting into the paradigm is a passive tracking index (PTI) methodology that is now used within WS to monitor pest species and to index wildlife populations for disease control purposes. Recently, scientists with the Murulle Foundation, a nonprofit charity committed to conserving the balance between cultural and natural resources in sub-Saharan Africa, collaborated with the Center biologist to test the PTI on African wildlife in the lower Omo Valley in Ethiopia. Application of the PTI demonstrated that hyenas, lesser kudu, dik dik, and baboons among other wildlife, could be monitored. For example, indices for these species were readily generated using tracking plots placed on dirt roads in the same way the system works on feral swine, coyotes, and deer in the United States. Based on this trial, Foundation scientists and the NWRC biologist are developing two collaborative funding proposals to apply the PTI in Ethiopia on other wildlife species.

Monitoring Dingoes on Townsend Island, Australia—An NWRC biologist collaborated with a biologist from the Queensland Department of Natural Resources during spring 2003 to analyze four years (1995–98) of PTI data for dingoes and potential prey species from Townsend Island along Queensland's coast. Townsend Island is the site where 16 dingoes were introduced experimentally in December 1993 to eradicate feral goats. In about 2 years, the dingoes eliminated the approximately 2,000 goats on the island. Only four goats managed to survive dingo predation by remaining on a nearly vertical cliff face and had to be removed by biologists.

The recently analyzed indexing data documented the survival of dingoes following their elimination of all large prey on the island and monitored their removal using poison baits. Introduction of dingoes into the highly controlled island situation was an efficient means to remove an invasive ungulate population. Vegetative analyses are being completed to monitor environmental responses to the removal of the goats.

Cooperation With the Queensland University of Technology (QUT) Graduate School—The QUT in Brisbane, Australia, has a considerable history of conducting research on wildlife damage issues. The common research interests of QUT and NWRC have resulted in several sabbatical exchanges between the two institutions and years of research cooperation and collaboration. As a result, an NWRC biologist from Fort Collins served as an external examiner for a QUT graduate student. The student's research topic was modeling the effects of spatial resource quality heterogeneity on connectivity among wildlife populations, followed by model validation using genetics.

The results showed that habitat features could be used to model and predict the connectivity between populations. This novel approach holds potential practical applications for WS, especially with respect to controlling wildlife diseases, as the techniques could be used to identify and target oral vaccine baiting toward areas where connectivity among subpopulations would promote the spread of disease. This knowledge could reduce costly applications of baits to areas where the spread of disease is less likely.

Indexing Mammalian Predators of the Puerto Rican Parrot—An NWRC biologist from Fort Collins collaborated in 2003 with WS operations, the USDA Forest Service, and researchers from University of California–Davis to collect and analyze population information on invasive mammalian species that pose predatory threats to the highly endangered Puerto Rican parrot. Roof rats, feral cats, and mongoose populations were indexed at sites within the Caribbean National Forest in parrot habitat, as well as around pubic-use areas such as picnic grounds. Roof rat populations were found to be among the highest reported in the literature throughout the world. Mongoose and feral cat populations were also high in all sample sites. Populations of each species appear to be higher within the forest than at the public-use sites. Parrots were observed to forage on the forest floor. Therefore, potential predation by cats and mongooses was evaluated and found to be a considerable threat to the parrots. This was evidenced by locating the radio transmitter from one of the eight 2003 fledglings in a mongoose burrow.

Previous research had demonstrated that predator control was a cost-effective management strategy for protecting parrots, and rat control was operationally implemented during the 2003 breeding season. The number of active parrot nests in the wild increased from three to five over the previous year, and the number of fledged birds increased from one to eight. This is a substantial benefit to a population that numbers only 30–40 birds in the wild.

Jaguar Predation on Livestock—
An NWRC biologist from the Logan, UT, field station has traveled several times to Brazil since May 2000 to work with a Utah graduate student who is examining jaguar predation on native prey species and domestic livestock. To date, eight jaguars and four cougars have been captured and radio-collared. GPS collars on jaguars have provided data on predation rates and sequences, prey species, age structure of depredated species, and movements. With approximately 15 months of data collection completed using the GPS collars, more than 6,000 locations have been sampled, and more than 200 kill sites have been identified.

Cottontail Rabbit Research in Australia—In July 2003, scientists from NWRC's Utah field station concluded a 7-year cooperative study with personnel from Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO) involving cottontail rabbits. CSIRO has supported a substantial research effort to investigate the potential for using immunocontraception as a means of managing introduced European rabbits in Australia. Part of CSIRO's effort involved evaluating the risk such programs might pose to other species of rabbits in other parts of the world if containment in Australia proves impossible.

Working with NWRC personnel, CSIRO researchers demonstrated gross differences in vulnerability to various myxoma viruses by two species of North American cottontail rabbits. Mountain cottontails developed pathology very similar to that of European rabbits, which typically ends in high mortality rates. Desert cottontails survived the myxoma viruses. The two species, despite very similar appearances and even being sympatric in some areas, also have marked behavioral differences in addition to the physiological differences.

VALUING AND INVESTING IN PEOPLE

2002 Publication Awards

NWRC Director Richard Curnow presented the 2003 Publication Award to the authors of the following Center publication: Glahn, J. F.; Dorr, B.; Harrel, J. B.; Khoo, L. 2003. Foraging ecology and depredation management of great blue herons at Mississippi catfish farms. Journal of Wildlife Management 66: 194–201. This publication is an excellent example of the quality of research being conducted by Center scientists and their collaborators.

Safety and Service Awards

Chronic Wasting Disease—In June 2003, NWRC Director Richard Curnow received a USDA Honor Award for his participation as an APHIS group member in the joint USDA–USDI Chronic Wasting Disease Management Task Force. This group recognition was for outstanding achievement in developing a plan to assist States and tribes in eliminating chronic wasting disease, thereby enhancing the health and safety of our Nation's animals.

APHIS Special Achievement Safety Awards—NWRC Starkville, MS, field station biologists Scott Barras and Brian Dorr received a Special Achievement Award from the APHIS Safety and Health Council for their life-saving efforts on September 16, 2002, in assisting a coworker during a medical emergency.

Jean Bourassa received a Safety and Health Special Achievement Award from WS for working under hazardous conditions from 1994 to 2001. The award was for continued safe performance in an environment with unexploded ordnance, the use of helicopters to capture waterfowl, working in a tidal area with 30-foot tides, and safe performance with motor vehicles and other transportation such as snow machines, canoes, and rafts in cold weather conditions.

Wildlife Society Outstanding Service Award—NWRC program manager Kathleen A. Fagerstone received an outstanding service award from The Wildlife Society in 2002 for serving as chair of the Wildlife Contraception Technical Review Committee. The review committee produced The Wildlife Society Technical Review 02–2, "Wildlife Fertility Control," and a position statement.

New Zealand Sabbatical—NWRC Chemist Tom Primus completed a sabbatical with Landcare Research in Lincoln, New Zealand, January through July, 2003. Dr. Primus' research focused on improving and developing new techniques and methods related to designing and implementing studies involving anticoagulants and assessing risk through cooperative studies with Landcare scientists.

INFORMATION AND COMMUNICATION

Goal: Collect and analyze internal and external information to monitor and enhance program effectiveness. Communicate internally and externally to accomplish NWRC's mission and to build an understanding of the Federal role in wildlife damage management.

INFORMATION SERVICES

Information Transfer—Three open houses for NWRC's new Outdoor Animal Research Facility were held in October 2003. The first included the media, CSU officials, heads of local Federal agencies, construction contractors, and APHIS and USDA officials. Two other open houses were held later in the month for NWRC's CSU Foothills campus neighbors and NWRC employees and their families. Tours of the facility were given and poster presentations on current work were displayed. About 150 individuals had an opportunity to see these new animal research facilities. The Outdoor Animal Research Facility will provide NWRC scientists and their collaborators with a much-needed environment to conduct studies that cannot be done in the field or indoor settings and also further APHIS' commitment to provide state-of-the art, humane housing of research wildlife.

NWRC Web Site—The NWRC Web site continues to grow. Web pages were added for the new Wildlife Disease Research Program's research projects and the Mammal Research Program's Nonlethal Predation Management Initiative. Sample copies of the most current APHIS vertebrate pesticide labels, as well as WS "Tech Notes," which provide information on the proper use of APHIS pesticide products and current information on NWRC's investigation of wildlife immobilizing and contraceptive agents, can be found on the Web at http://www.aphis.usda.gov/ws/nwrc/RegUnit.htm under the Registration Unit section. New additions on the History page detail the history of the NWRC Hilo, HI, field station, the historical name changes of the National Wildlife Research Center, and the role of the Denver Wildlife Research Center during World War II.

The full text of the "Human Conflicts with Wildlife: Economic Considerations" symposium proceedings, the NWRC Accomplishments 2002 report, and more than 100 NWRC-authored publications were scanned and uploaded to the Web site.

The NWRC information specialist is a member of the APHIS Web Access Team, which is charged with developing standards and guidelines for the APHIS Web site. Representatives from each program within APHIS are collaborating with APHIS Legislative and Public Affairs to create Web page templates, policy guidelines on Web site content, and a standard "look" that provides consistency throughout the agency's Web presence. The team is now developing a taxonomy that will greatly enhance the ability of users to locate information on the APHIS Web pages faster and more accurately.

Toxicology Database—In cooperation with a retired NWRC scientist, Center personnel are developing a fully searchable, electronic toxicology database (DRC Database—Denver Research Center). This database contains data for 6,800 chemicals that were screened for toxicological and repellancy properties at the Denver Wildlife Research Center between 1960 and 1987. This database provides rapid access to the results of more than 23,000 individual toxicity tests conducted with up to 127 species (7 plants, 84 birds, 32 mammals, and 1 amphibian). A printed copy of the contents of this database was published in 2003 as part of the NWRC Research Report series and is available from the NWRC Library. Additionally, ongoing efforts will allow posting the entire database in a searchable form on the NWRC Web site.

A new "Information Alert" e-mail newsletter was designed and put into action. The newsletter contains brief articles on new products and services such as ABSEARCH and CFRLite, purchased by the library, and lists of new books and NWRC publications. Recent issues have included information on the USDA DigiTop project and tips on how to use digital cameras more effectively.

The WS Image Collection, a database of photographs and other images illustrating the work of the program, was loaded into the Contentdm™ database software in May 2003 to create a Web-based image database. Users can search for images by keyword, creator, or title and download the images onto their desktops. An additional feature allows users to load images directly into PowerPoint™ to create presentations automatically. The database currently contains 1,980 images and will be a great tool in organizing the many slides and photographs owned by NWRC and WS operations. New material will be added on a regular basis, and the database will be made available to WS staff in October 2003.

Library—The primary focus of library staff in 2003 was to enhance digital access to library services. To this end, intensive preparations were undertaken in anticipation of implementing a new online catalog system. NWRC joined the Automated System Consortia—Colorado (ASCC), which employs Horizon™ software, and the Center library will switch from the current GLAS system to the new software in the first quarter of fiscal year 2004.

To ensure that the new online catalog accurately reflects library holdings, a shelf inventory was begun in the spring. An NWRC library profile, listing all functions and parameters needed by the library to successfully operate under the Horizon software system, was prepared and tested. Staff undertook extensive external and in-house training by Dynix, producers of the Horizon software, in anticipation of conversion to the new system in October 2003.

The USDA National Agricultural Library, through its Digital Desktop initiative, purchased access for all USDA employees to multiple informational and scientific databases. The resultant package of databases, accessible as "DigiTop," provides bibliographic and full-text access to information in the life sciences for all WS employees. NWRC library staff have coordinated with the National Agricultural Library to ensure that all WS employees can use this immensely valuable resource.

New reference products purchased for WS library customers include WildPro, a wildlife disease database; ABSEARCH Wildlife, which provides full text access to the Wildlife Society journals; and the Encyclopedia Americana. WS employees can now access these databases from their desktops nationwide.

Information Services Unit staff borrowed or photocopied almost 2,400 items from other libraries in response to information requests from the WS program and lent almost 230 items in return. Additionally, staff photocopied nearly 4,000 in-house journal articles, reports, and NWRC-authored reprints for distribution to Center researchers and WS operations staff. Nearly 6,000 other NWRC or WS information products were distributed, including children's activity sheets and information packets. Almost 150 new items were added to the NWRC catalog, including theses, dissertations, reports, proceedings, and reference items. Overall reference information requests totaled nearly 400, with almost a third of the requests arriving via e-mail via the NWRC Web site. Online searches performed by library staff numbered around 125.

Archives—The Records Management and Archives staff held its second annual Archives Week in October 2002. Activities included daily e-mails regarding NWRC history and an Archives open house. A computer slide show in the Archives, during the open house, featured NWRC vampire bat work in South America. Archives Week is held to highlight the NWRC Archives and provide staff an opportunity to view interesting historical records.

In April 2003, the Records Management and Archives staff held Records and Information Management Week. Several e-mails throughout the week stressed the importance of records and recordkeeping. The event included exhibits and records-oriented word searches and crossword puzzles. While the focus of Records and Information Management Week is different than Archives Week, the theory is the same: to highlight records and provide information.

Exhibits—In February 2003, a new display was installed in the NWRC hallway exhibit case. "A Great Idea With a Catch: NWRC Capture Device Research" featured the history of NWRC's work on various capture devices. The display highlighted the fact that over the years, traps have become more humane, effective, and selective. A nearby computer featured audio clips and slide shows. In addition, an audio display provided information on mountain beaver live traps.

General Archival and Records Management Work—A major ongoing project involves NWRC unpublished material that was transferred to the National Archives and Records Administration (NARA) branch in Denver in the late 1970s. Through a Memorandum of Understanding, NWRC regularly receives the records, provides holdings maintenance, and updates the NWRC catalog to better organize the material. NWRC Archives staff has completed work on 17 of 31 boxes of material; the anticipated ending date for this project is summer 2004. This project is vital to the accessibility of the material. The NARA records are NWRC's historical memory, and thus, preserving them is extremely important.

In April 2003, a 2-year project was completed that involved updating the NWRC author reprint collection. NWRC scientists have published a total of 11,230 publications between 1931 and 2003. The project accomplished the following tasks: (1) 297 missing items were located, copied and placed in folders; (2) 193 items by NWRC authors not originally on old publication lists were added; and (3) all related record entries in the NWRC online catalog were corrected. The massive time and effort involved underscores the need to have NWRC author publications accessible and cataloged. To date, NWRC has copies of all but three NWRC publications.

During the spring semester of the 2002–03 academic year, a CSU history graduate student inventoried 29 rolls of film stored in the NWRC Archives. The student researched, and in some cases viewed the film, to make recommendations about disposition and storage of the items. Several of the films could not be viewed due to lack of old equipment or a concern for the films' stability. Topics of films of NWRC work hat could be viewed included Quelea birds; 1960s research at Sand Lake Refuge in Brown County, South Dakota; and National Geographic's "Creatures of the Night," which discussed the Center's vampire bat control in Central America. Through the student's effort, the Archives now has a much better idea of the content of its film collection and recommendations for preservation and use.

SEMINARS

The NWRC seminar program offers a valuable forum for the exchange of ideas among Center staff, field station personnel, visiting scientists, and WS staff. During 2003, NWRC hosted 23 seminars, including presentations by speakers from various universities and foreign wildlife organizations, NWRC headquarters and field station staff, and potential candidates for employment. Presentations were videotaped and distributed on CDroms to Center, field station, and WS regional offices for viewing. Topics included wildlife diseases, genetics in wildlife management, avian migration, aquaculture, invasive species eradication, prairie dog research, and an NWRC Quality in Science Series. The Quality in Science Series, which was conducted by the NWRC Quality Assurance Unit, is a training program that promotes continual improvement in the quality of NWRC research.

NWRC Seminars

Speaker	Affiliation	Topic
Cathy Bens, Laura Greiner	NWRC, Fort Collins	**NWRC Quality in Science Seminar Series** Data documentation techniques and requirements Final reports and archiving Role of the study director Standard operating procedures
Cathy Bens, Laura Greiner, Steve Greiner		Protocol development and approval
Cathy Bens, Laura Greiner, Jerry Hurley		Test, control, and reference substance handling
Bruce Kimball	NWRC, Fort Collins	Deer browse and fried ham sandwiches
Christen Williams	NWRC, Fort Collins	Applications of genetics in wildlife management
Jenny Powers	NWRC, Fort Collins	Emerging technologies in oral rabies vaccine design
Ross Cullen, Kenneth Hughey	Lincoln University–Canterbury, New Zealand	Cost-utility analysis of endangered species programs
Josh Dein	USGS, National Wildlife Disease Center, Madison, WI	The wildlife disease information node
Bob Beason	NWRC, Sandusky, OH	Sensory perception in avian migration and navigation
Holly Gaff	University of Tennessee, Knoxville, TN	Spatial tick-borne disease model: spread and control
David Hewitt	Caesar Kleberg Wildlife Research Institute, Texas A&M University, Kingsville, TX	Biological and cultural crossroads—wildlife research in southern Texas
Aaron Schwartz	Colorado State University, Fort Collins	Surgical sterilization of the black-tailed prairie dog: a model for the effects of reproductive inhibition and hormonal reduction in the male

NWRC Seminars (continued)

Speaker	Affiliation	Topic
Scott Barras	NWRC, Starkville, MS	Introduction of the NWRC Mississippi field station
Brian Dorr	NWRC, Starkville, MS	Distribution and abundance of double-crested cormorants on catfish aquaculture ponds in the delta region of Mississippi
Mohammad Ahsan	Rana Pratap Marg Lucknow, India	Wildlife conservation in fragmented forests in northern India
Jack Rhyan	USDA–APHIS–Veterinary Services	A great American tale or hate to let the truth get in the way of a good story
Jerry Hill	M.S. candidate, Forestry, Range and Wildlife Resources Department, Utah State University	Wildlife–cattle interactions in northern Michigan: implications for the transmission of bovine tuberculosis
Jessica Montag	Ph.D. candidate in wildlife biology, University of Montana, Missoula, MT	Compensation programs as conservation tools: public perceptions toward predator compensation in the Rocky Mountain West
Gary Witmer	NWRC, Fort Collins	Overview of the NWRC Rodent Damage Research Project
Gregg Howald	Island Conservation Ecology Group, Kelowna, BC	Invasive species eradication efforts on the West Coast
Stephanie Halse	Foundation for Arable Research, New Zealand	Bird management in seed crops—New Zealand's experience and research
Tom Primus	NWRC, Fort Collins	Playing possum in Kiwiland
Gary Beauchamp	Monell Chemical Senses Center	Chemical senses and wildlife management: contributions from the Monell Center

MEETINGS, WORKSHOPS, AND CONFERENCE PRESENTATIONS

Carnivore Predation Management Workshop in Brazil—A scientist from the NWRC Logan, UT, field station presented an invited lecture entitled "Management of Carnivore Predation as a Means To Reduce Livestock Losses: the Study of Coyotes *(Canis latrans)* in North America" at the first Workshop on Research and Conservation of Neotropical Carnivores, held May 13–18 in Atibaia, Brazil. This 6-day workshop was attended by 80 people ranging from conservation biologists to disease specialists, geneticists, ecologists, and government officials in an attempt to prioritize conservation planning and research actions for 26 carnivore species in Brazil. The workshop produced a planning document to be used by governmental and nongovernmental natural resource agencies and organizations to establish collaborations and set funding priorities.

Depredation on Aquaculture Research Seminar—In June 2003, a scientist from the NWRC Mississippi field station presented a lecture to 38 undergraduate students enrolled in the Mississippi State University College of Forest Resources' Forestry Summer Camp in Starkville. The seminar and tour of the field station focused on NWRC's mission and research programs, with a detailed overview of NWRC studies on bird depredation on aquaculture in the southeastern United States. The biologist discussed the role of wildlife damage research within the wildlife management field and shared with the students how to use research results to design specific tools and management strategies for use in reducing human–wildlife conflicts.

Hawaii Farm Bureau Federation Presentation—In June 2003, at the invitation of the Hawaii Agricultural Research Center, an NWRC scientist from the Hawaii field station presented a talk in Honolulu to the Hawaii Farm Bureau Federation Commodity Advisory Group. The scientist gave a general overview of WS' organization and function, emphasizing NWRC's research staffing and expertise, facilities, and past and current work. Research capabilities of the Hilo field station and the field station's role in Hawaiian agricultural research were highlighted as well. The meeting was attended by about 30 representatives from Federal and State agencies, the Hawaiian Agricultural Research Center, and farmers' associations.

Hawaii Conservation Conference—Scientists from the NWRC Hawaii field station attended the Hawaii Conservation Conference July 10–11, 2003. Participants from State and Federal agencies, academia, and private conservation groups and concerned citizens involved in the protection and management of Hawaii's native species attended. The conference was a mechanism to facilitate interaction between resource managers and the scientific community on Hawaiian forest issues. An NWRC researcher presented a paper on the use of dermal toxicants as an effective management tool to control and eradicate the invasive coqui and greenhouse frogs from Hawaii.

Heinz Center Invasive Species Meeting—Several personnel participated in an invasive species presentation at the Heinz Center Task Team on Invasive Species Meeting on August 14, 2003. Representatives from APHIS, the National Park Service, the Bureau of Land Management, the USGS, the Forest Service, and CSU made formal presentations

and showed exhibits about their agencies' plant and animal invasive-species research data. The Heinz Center is a nonprofit institution dedicated to improving the scientific and economic foundation for environmental policy through multisectoral collaboration among industry, government, academia, and environmental organizations.

Red Wolf Recovery Implementation Team Meeting—A wildlife biologist from NWRC's Utah field Station participated in the fall meeting of the Red Wolf Recovery Implementation Team, August 9–10, 2003, in Columbia, NC. This group of academic and agency scientists meets twice a year to review progress on USFWS' Red Wolf Adaptive Management Plan and to make suggestions and/or recommend modifications of procedures and data requirements.

Thus far, the plan to maintain a wild population of red wolves by removing or sterilizing coyotes and coyote–red wolf hybrids appears to be effective. Current information suggests red wolf numbers have increased 170 percent and the number of breeding pairs may be up as much as 2.7-fold in the past 3 years. There is a possibility that the current red wolf management zone may become saturated within the next 2 to 3 years.

West Nile Virus and Birds Symposium—An NWRC scientist was the cochair of the West Nile Virus and Birds Symposium at the American Ornithologists' Union meeting in Urbana–Champaign, IL, August 6–9, 2003. He also presented a talk on "West Nile Virus in North American Birds: Emergence of a Disease Threat." Three scientists from NWRC attended the Wildlife Disease Association meeting and the International Chronic Wasting Disease Workshop in Saskatoon, Saskatchewan, August 11–15.

Bird Strike Committee (BSC)–USA and Bird Strike Committee–Canada Annual Meeting—More than 200 people and 17 exhibitors from 20 countries attended the fifth annual joint meeting of Bird Strike Committee–USA and Bird Strike Committee–Canada in Toronto August 18–21, 2003. In all, 34 technical papers and posters were presented, including 6 by scientists from NWRC's Sandusky, OH, and Philadelphia field stations on topics related to reducing wildlife collisions with aircraft. The goal of BSC–USA is to increase communication and professionalism among the diverse groups dealing with wildlife issues on airports, and the 2003 meeting appeared to be highly successful in this regard. WS biologists play an increasingly important role in reducing wildlife hazards at U.S. airports, assisting at 544 airports in 2002.

Tenth Annual Wildlife Society Meeting—Several NWRC scientists attended the 10th annual conference of The Wildlife Society, held in Burlington, VT, September 6–10, 2003. NWRC scientists were involved in presentations and/or poster sessions on protection of endangered sea turtles, management of invasive monk parakeets, and wood stork and cormorant impacts to aquaculture. NWRC research on the economics of wildlife rabies, protection of riparian habitats from beaver, and secondary toxicity of strychnine for pocket-gopher control were covered as well. The Wildlife Society conference brings together researchers and wildlife managers from across the United States.

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[Boldface type indicates an NWRC author.]

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